Self-Adaptability and Organization in Pervasive Computing Environments using Biologically-inspired Approaches

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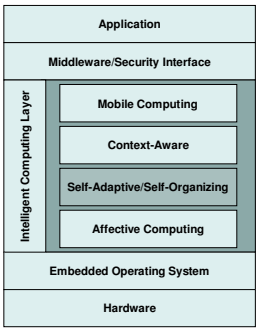
Overview

- Architecture for Pervasive Computing
- Self-Organization and Self-Adaptive
- Attractor Selection Mechanism
- Application to Clustering 1
- Application to Clustering 2
- Conclusion
- Future Work

The Architecture for Pervasive Computing



Self-Organization and Self-Adaptation

- "Any dynamic system will eventually *evolve* towards a state of equilibrium"
  - This state is defined as an *attractor*.
  - A system tries to reach a pattern, point of stability or recurrence.
- A self-organizing system can emerge without a centralized control with simple rules followed by each node.
  - Feedback from surrounding nodes and environment.
- A self-adapting system will dynamically adapt to changes in its environment using feedback from its immediate environment.

Attractor-Selection Mechanism

$$\frac{dx_i}{dt} = f_i(x_1,\ldots,x_N)\alpha + \eta_i \qquad i = 1,\ldots,N$$

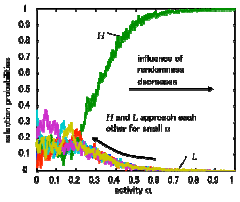
$$\frac{dx_i}{dt} = \frac{s(\alpha)}{1+x_{\max}^2 - x_i^2} - d(\alpha)x_i + \eta_i \qquad i = 1,\ldots,N$$

$$\frac{d\alpha}{dt} = \rho(\tilde{\alpha} - \alpha)$$

- $\tilde{\alpha}$ is a measured target value
- α a non-negative function representing the cell's growth rate and is related to its activity.
- ρ is the rate of adaptation.
- f_i Define the attractors to which the dynamic orbit of the system will eventually converge in spite of the existence of an inherent noise term.
- η_i Inherent noise term.

Attractor Selection in a gene network

$$\frac{dn}{dt} = f(n)\alpha + \eta$$



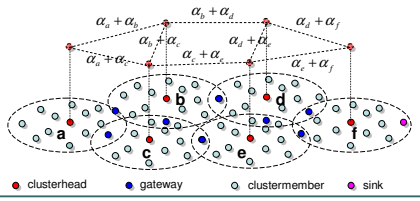
- ***n*** represents a property for selection.
- ***f(n)*** is a function defining the attractors.
- ***α*** is the activity, the "goodness" of the selection.
- ***η*** is a Gaussian noise term for inducing random selection.

Attractor Selection for Clustering

$$\frac{dx}{dt} = f(x)\alpha + \eta$$

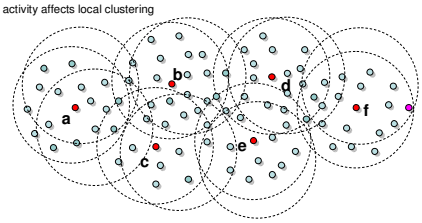
$$\frac{dy_i}{dt} = f(y_i)\alpha_i + \eta$$

x defines the global object's parameter (e.g. no. of clusters)
y_i defines the local parameter (e.g. local clusterhead election)
α is the global activity
α_i is the local activity.



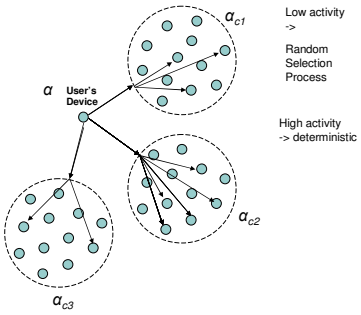
Attractor Selection for Clustering

Local activity affects local clustering



Global activity affects all clusters

Attractor Selection for Cluster Information Retrieval



Conclusion

- Introduced the concept of layered attractor selection model
  - a biologically-inspired approach for self-adaptation and self-organization in a pervasive environment.
- Two applications were illustrated
  - Layered attractor selection for clustering in a wireless sensor network
  - Layered attractor selection for information retrieval in a clustered network.

Future Work

- Application of attractor selection model to various scenarios.
  - Recurring patterns of mobility, traffic, and other measurable metrics, which may be subjected to perturbation and temporal obstruction.
- Implementation and simulation of attractor selection model in real world scenarios.

Thank You.